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NOTES ON THE MORPHOLOGY OF THE EMBRYO AND SEEDLING OF *STRELITZIA REGINAE* AIT.

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Abstract

The embryo of *S. reginae* is an elongated, club-shaped organ, the bulk of which consists of a massive cotyledon. Germination is hypogeal. The apex of the cotyledon, corresponding to the leaf blade, remains in the seed during germination and functions as a haustorium. Elongation growth of the basal portion of the cotyledon carries the plant axis into the soil. A short cotyledonary petiole separates the plant axis from the haustorium.

Proliferation of cells around the cotyledonary cleft results in the formation of a ligule while extensive elongation of the basal portion of the cotyledonary sheath is absent.

The first leaf to emerge from the ligule is a tubular scale leaf while the second leaf to appear is the first laminate leaf.

Uittreksel

AANTEKENINGE OOR DIE MORFOLOGIE VAN DIE EMBRIO EN SAAILING VAN *STRELITZIA REGINAE* AIT.

Die embrio van *S. reginae* is 'n verlengde, knuppelvormige orgaan waarvan die grootste gedeelte uit die saadlob bestaan. Ontkieming is hipogeaal. Die apikale gedeelte van die saadlob, wat ooreenstem met die blaarskyf, bly in die saad gedurende ontkieming en funksioneer as 'n houstorium. Verlenging van die basale gedeelte van die saadlob dra die plantas in die grond in. 'n Kort saadlobpetiolus skei die plantas van die houstorium.

Proliferasie van selle rondom die saadlobspleet lei tot die vorming van 'n liguul terwyl uitgebreide verlenging van die saadlobskede self, afwesig is.

Die eerste blaar wat deur die liguul verskyn is 'n buisagtige skubblaar terwyl die tweede blaar die eerste is wat 'n blaarskyf besit.

Introduction

Aspects of the embryology of *S. reginae* have been investigated by Mauritzon (1936) and van de Venter (1975) while the anatomy of the seed has been described by Humphrey (1896). The embryogeny of this species has not been described, nor has a description been given of the morphology of germinating seeds.

This paper reports on an investigation into the morphology of the mature embryo and the young seedling.

Material and Methods

Embryos and seedlings of *S. reginae* were fixed in Craf II solution (Sass, 1958). Dehydration was accomplished in a dioxan-tertiary butyl alcohol series (Sass, 1958) before embedding in wax (Carowax; melting point 54–58°C).

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Sections were cut on a Jung model 1130 rotary microtome at a thickness of 10 μm. Sections were stained with the iron-alum-hematoxylin safranin stain of Brooks, Bradley & Anderson (1950) and photographs taken with a Zeiss photomicrographic camera using Kodak Panatomic X film.

Results and Discussion

In the "ripe" or mature seed of *S. reginae* the embryo lies within a cavity in the endosperm (Fig. 1). The embryo is not attached to any part of the seed structure and can be removed simply by cutting through the surrounding tissue and splitting the seed in half.

The embryo is an elongated, club-shaped organ which, after imbibition, is more or less circular in transverse section. It is about 7 mm long and extends from the micropyle to a point approximately 0,6 mm below the testa on the opposite side of the seed.

The bulk of the embryo consists of the massive cotyledon. The portion corresponding to the leaf blade is separated from the basal portion of the embryo, which contains the radicle and plumule, by a slight constriction. The former portion remains in the seed during germination and serves as a haustorium. The different parts of the embryo are shown in Fig. 2. Several procambial strands extend from the basal portion to the apex of the embryo.

The basal portion of the embryo contains the plumular bud and radicle. The plumular bud is surrounded by the cotyledonary sheath which, as can be seen in a transverse section (Fig. 3), contains a narrow cleft. This cleft is formed as a result of the narrowing down of the cotyledonary indentation in the developing embryo (Fig. 4) by the growth of the surrounding tissue.

The radicle apex lacks a clear differentiation of initials (Fig. 5). This is classed as the open type of organization (Von Guttenberg, 1960) in which the tissue regions (central cylinder, cortex, root cap and protoderm) merge in a common group of initial cells (i in Fig. 5). A prominent root cap overlies the radicle.

The embryo requires no further differentiation or growth as a prerequisite for germination as has been demonstrated by the fact that isolated embryos grow promptly when placed in a suitable medium (van de Venter & Small, 1974).

With the commencement of germination a zone of cotyledonary tissue between the sheathing base and haustorium elongates resulting in the rupture of the testa. As a result of this extension growth the primary seedling axis is carried out of the seed into the soil.

The primary root with its prominent root cap is the first portion of the embryo to emerge. In the mature embryo the epidermis of the root cap, and not the protoderm of the young radicle, is continuous with the epidermis of the cotyledon (Fig. 5). The result is that extension growth of the radicle ruptures

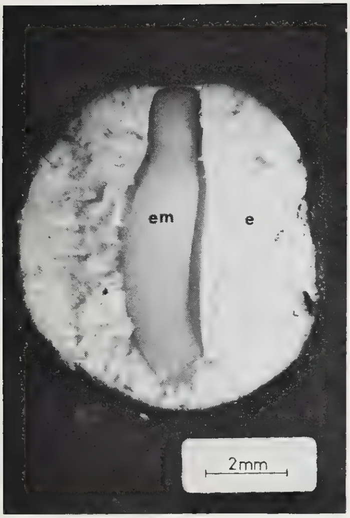

FIG. 1.
Imbibed seed of *S. reginae* split in half to show embryo. (em—embryo; e—endosperm).

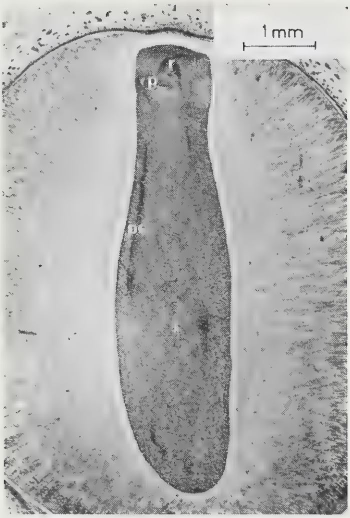

FIG. 2.
Longitudinal section of a mature embryo of *S. reginae* (c—cotyledon; pc—procambium; p—plumular bud; r—radicle).

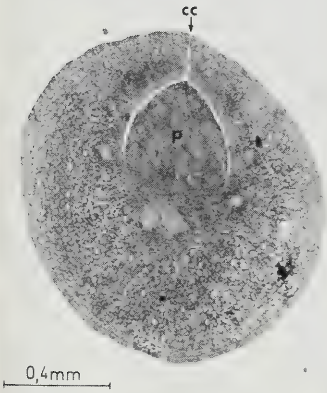

FIG. 3.
Transverse section of an embryo of *S. reginae* at the level of the plumular bud. (cc—cotyledonary cleft; p—plumular bud).

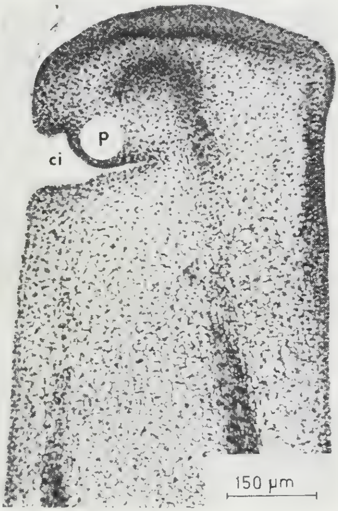

FIG. 4.
Longitudinal section of a developing embryo of *S. reginae* (ci—cotyledonary indentation; p—developing plumule).

the epidermis of the embryo (see arrows in Fig. 6) and the epidermis of the primary root is not continuous with that of the rest of the seedling.

Germination is hypogeal. The mode of germination corresponds to the type C in the classification of Boyd (1932). The following description assumes that the long axis of the embryo is aligned parallel to the soil surface before germination commences. At first the axis of the embryo emerging from the seed is not directed vertically downwards, but at an obtuse angle to the axis of the haustorium. In their final orientation, however, the plumular bud and the radicle are in a vertical alignment at right angles to the cotyledon haustorium. The seedling axis is separated from the haustorium by a short (about 2 mm in length) stalk or cotyledonary petiole (Fig. 7).

The basal portion of the cotyledonary sheath does not elongate to form a prominent sheathing organ, as is the case with some monocotyledonous species (Tomlinson, 1960). However, proliferation of cotyledonary sheath tissue on the margins of the cotyledonary cleft results in the formation of a ligule (Figs. 7 and 8). Boyd (1932) regards production of a ligule coupled with the disappearance of the lower sheath to be an advanced characteristic.

The first foliar organ to be produced from the plumular bud appears through a small pore at the apex of the developing ligule when the primary root has attained a length of about 8 mm (Fig. 7). The first leaf to emerge is a scale leaf—a tubular, sheathing organ. The second leaf is the first laminate leaf.

The part of the cotyledon corresponding to the leaf blade remains permanently in the seed and functions as a suctorial structure. The endosperm cells are filled with amyloplasts (Fig. 9) and the starch in these organelles is, no doubt, broken down and absorbed by the haustorium with subsequent transport to the developing seedling. Apart from the increase in volume as a result of imbibition, the cotyledon does not change in shape during or subsequent to germination, nor do any special epidermal modifications differentiate. Such changes occur in the cotyledons of many monocotyledonous species (Eames, 1961).

Anatomical changes do however, take place in the haustorium after commencement of germination. The procambium strands differentiate into vascular tissue (Fig. 10). The number of vascular bundles per cotyledon is not constant but varies from seven to eleven. The xylem is situated on the inner side of each vascular bundle, that is, it is directed toward the central axis of the cotyledon. Scalariform and pitted vessels are shown in Fig. 11. An abundance of phloem tissue is differentiated on the outer side of the vascular bundles.

The primordium of the first adventitious root is visible (upon sectioning) before the first leaf emerges from the ligule. By the time the third laminate leaf appears, the first adventitious root is as long as the primary root (about 10 cm). When the sixth laminate leaf becomes visible, the root system consists of three to five prominent, fleshy adventitious roots.

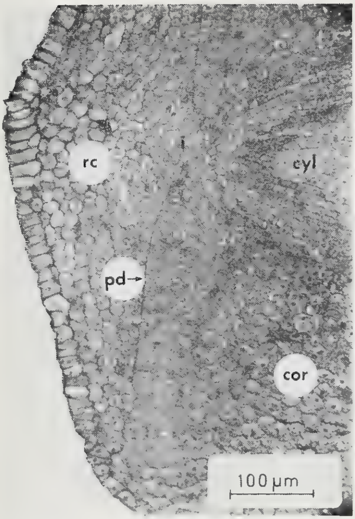

FIG. 5.
Longitudinal section of a radicle of an embryo of *S. reginae* (cor—cortex; cyl—central cylinder; i—initial cells; pd—protoderm; rc—root cap).

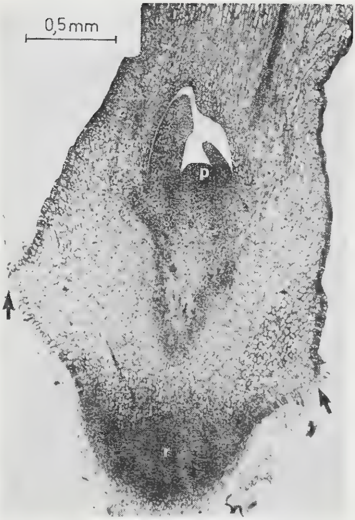

FIG. 6.
Longitudinal section of the plant axis of *S. reginae* shortly after germination. (p—plumule; r—radicle).

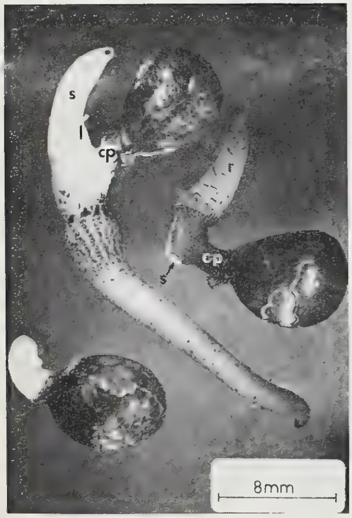

FIG. 7.
Germinating *S. reginae* seeds. (cp—cotyledonary petiole; l—ligule; r—radicle; s—scale leaf).

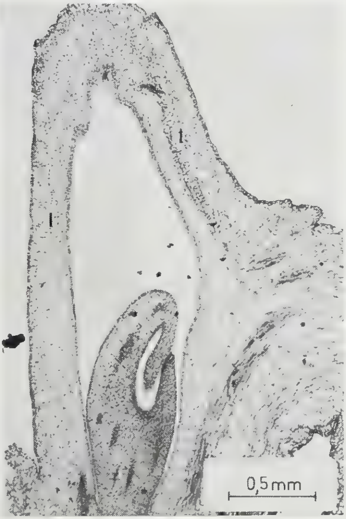

FIG. 8.
Longitudinal section of plumule and ligule of a *S. reginae* seedling. (l—ligule).

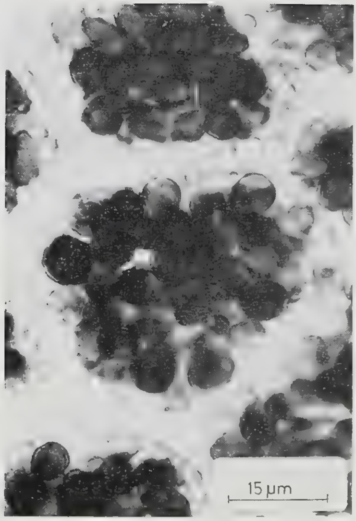

Fig. 9.
Section of endosperm cells in a seed of *S. reginae* showing amyloplasts stained with I_2KI.

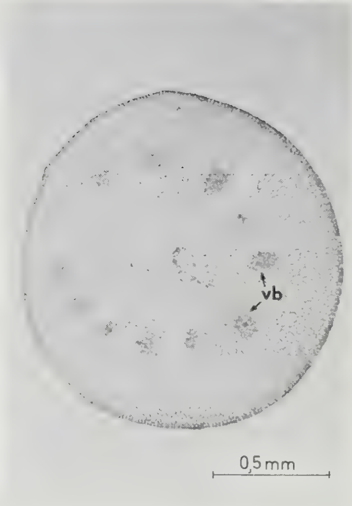

Fig. 10.
Transverse section of the haustorium in a germinated seed of *S. reginae* (vb—vascular bundles).

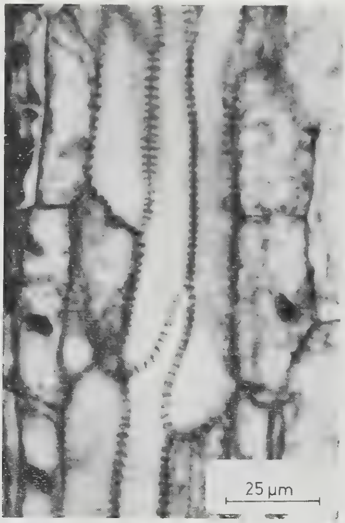

Fig. 11.
Longitudinal section of the xylem in a haustorium of a germinated seed of *S. reginae*.

ACKNOWLEDGEMENTS

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